Critical-Size, Critical-Period Hypothesis: An Example of the Relationship between Early Marine Growth of Juvenile Bristol Bay Sockeye Salmon, Subsequent Marine Survival, and Ocean Conditions

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Bristol Bay sockeye salmon (*Oncorhynchus nerka*) from the eastern Bering Sea were used to test the critical-size, critical-period hypothesis (Beamish and Mahnken 2001; Beamish et al. 2004). We examined a time series (42 years) of survival (brood year return per spawner from the Kvichak and Egegik river systems in southwest Alaska) and early marine growth (mean circuli spacing for the first marine year) from preferred scales (Clutter and Whitesel 1956) collected from returning adult salmon to these river systems. Four major age classes of sockeye salmon return to Bristol Bay, including 1.2, 1.3, 2.2, and 2.3, where the numbers to the left and right of the decimal point indicate the number of years spent in freshwater lakes and the number of years in the ocean, respectively. The data were lagged to reflect growth during the first year at sea (1958–2000) for freshwater age 1.0 and 2.0 sockeye salmon. Early marine growth was compared with survival of adult sockeye salmon using regression analysis and was found not to be significantly related to survival of Bristol Bay sockeye salmon. We also compared early marine growth between river systems for each freshwater age class and between freshwater age classes. Average circuli spacing between Egegik and Kvichak age 1.0 and 2.0 salmon was relatively uniform as was average circuli spacing between age 1.0 and 2.0 fish. A lack of relationship between adult sockeye salmon survival and early marine growth as observed from scales of surviving adult sockeye salmon may indicate a threshold relationship between early marine growth and survival, implying that those fish failing to achieve a sufficient size undergo higher mortality rates (Crozier and Kennedy 1999). Moreover, the similarity in early marine growth between river systems and freshwater age classes is an indication that the early marine growth threshold is correlated among geographically well-separated river systems and between freshwater age classes.

The threshold size of sockeye salmon was compared to the size of juvenile Bristol Bay sockeye salmon collected during eastern Bering Sea research cruises in August–October of 2000–2004. The results indicate that juvenile sockeye salmon were significantly smaller during 2000 and 2001 and not significantly different during 2002–2004 than the threshold size. We speculate that the larger size of juvenile Bristol Bay sockeye salmon during 2002–2004 is related to higher early marine growth rates that may be due to improved or changing ocean conditions along the eastern Bering Sea shelf beginning in 2002. These results indicate that growth of juvenile Pacific salmon may be an excellent indicator of ecosystem change.

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